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TEXAS AGRICULTURAL EXPERIMENT STATION

A. B. CONNER, DIRECTOR
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DIVISION OF VETERINARY SCIENCE

Bitterweed Poisoning in Sheep

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**In cooperation with U. S. Department of Agriculture.

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Bitterweed, *Actinea odorata* (DC.) Kuntze, has been shown to be poisonous to sheep. This plant grows from Kansas south to Mexico and from central Texas west to California. In Texas it occurs in greatest abundance in the Edwards Plateau region. It is an annual plant and for many years was confined to basins and low areas. During the last several years it has spread to higher ground so that it now occupies large areas of the previously best grazing land on some ranches. Simultaneously with the spread of the bitterweed heavy losses among sheep due to the poisoning from this plant have been experienced.

The amount of bitterweed an animal must consume to cause symptoms of poisoning varies considerably. In one case as little as 500 grams of the immature green plant administered in two days caused death of the animal, while another animal, consuming 1100 grams of the same material in 11 days, remained healthy. Bitterweed poisoning may manifest itself in sub-acute poisoning when only a small quantity of the plant is consumed or in acute poisoning when larger quantities are taken. Many of the sub-acute cases will recover if the sheep are removed from bitterweed range when the first symptoms appear and offered supplemented feed while the acute cases rapidly terminate in death. The symptoms of bitterweed poisoning are such as loss of appetite, cessation of rumination, depression, indications of abdominal pain, bloat, frothing at the mouth and a green discharge from the nose. Lesions particularly noticeable in bitterweed poisoning are congested areas in the intestinal tract, marked congestion of the lungs, hemorrhages on the external surfaces of the heart and congestion or hemorrhages of the lymph nodes of the head.

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BITTERWEED POISONING IN SHEEP*

W. T. HARDY, V. L. CORY, H. SCHMIDT, W. H. DAMERON

On the sheep ranches in the Edwards Plateau region of Texas much sickness and some deaths have been observed in sheep in recent years, which the older sheepmen had not previously observed in spite of their long experience in the sheep business. The symptoms exhibited by the sick sheep were rather of a general character such as listlessness and general depression. They probably would not follow the flock or would lag behind and walk or stand with an arched back, likely as an indication of abdominal pain. Often they would show a greenish discharge from the nose which would also stain the muzzle. Occasionally a sheep was even observed to vomit. When such sheep were subjected to forced exercise they would soon tire out and fall or lie down to remain there until they had become rested. Observation has shown that when sheep in the early stages of this trouble were taken off the range and well cared for many would recover.

The green discharge from the nose was the thing that caught the sheepman's eye and he soon associated it with a bright green plant that had only in recent years established itself in great abundance on his ranch. This plant, on account of its extremely bitter taste, he called bitterweed and is known to the botanist as *Actinea odorata* (DC.) Kuntze. The plant and the disease were both new to the ranchman but it did not take long until it was noticed that where the plant had not yet gained a foothold the disease was not observed. The complaints from such losses were not numerous at first but as the weed spread the complaints also increased in number.

The losses have been observed to be rather seasonal, beginning soon after the young bitterweed makes its appearance in great abundance in December or January and continuing until early spring when the grass puts in its renewed growth. This observation is an important one and probably holds the key to the whole bitterweed problem. That sheep on the range eat the plant, at least in small quantities, was soon established by observation, but whether the sickness and losses are caused by its consumption remained to be determined.

BOTANICAL DESCRIPTION OF THE PLANT

Bitterweed is classified as belonging to the section Hymenoxys of the genus Actinea, which in turn belongs to the Helenium tribe of the composite family. Its botanical name is *Actinea odorata* (DC.)

*Some of the data reported herein were recorded by E. A. Tunnicliff and Erwin Jungherr, resigned.

Kuntze, and was originally described by De Candolle from a collection of plants made in Mexico by Berlandier almost a century ago. The plant is an annual and under favorable conditions grows to about two feet tall. It is usually branched at the base and above, the branches being ascending and leafy and terminating in small heads. (Fig. 1.) A noticeable feature of the stem consists in its usually purplish color

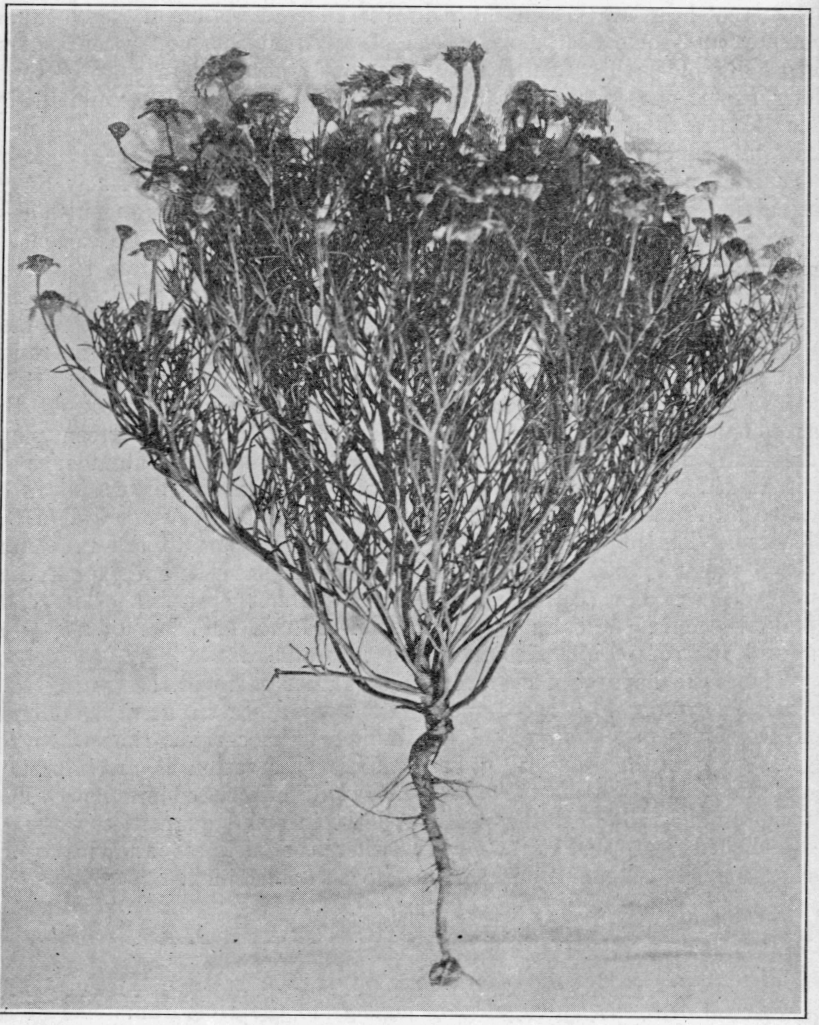

Figure 1. A fairly typical bitterweed plant of late season growth somewhat stunted by dry weather and not influenced by crowding. (Specimen collected August 12, 1931.) Plants in full flower in April were much taller.

towards its base. The leaves are alternate, once to thrice parted into thread-like segments which are not rigid, are glandular dotted throughout and floccose-woolly, especially on the under surface. The heads are few or numerous, in accordance with the branching of the plant, slender stalked, and consist of 60 or more disk-flowers and 6 to 10 ray-flowers, a total of 66 or more flowers. The involucral bracts are rigid and are in two series, the outer series being united at the base. The ray-flowers are bright yellow, corolla ligulate, petals wedge-shaped, three-lobed at the expanded apex, and a quarter of an inch in length. In full flower the head is three-fourths of an inch wide, more or less, fully one-third of which is due to the diameter of

Figure 2. A flowering sprig of bitterweed somewhat enlarged, showing character of flower and foliage.

the disk. The one-seeded fruit (achene) is broadest upward, is densely hairy, and has a pappus of several awned or sharply pointed, very thin, chaffy scales. A prominent characteristic of this plant is its aromatic odor and its bitter taste. It is allied to a group of plants known as "rubberweeds."

DISTRIBUTION OF BITTERWEED

The reported distribution of this species of bitterweed extends from Kansas south into Mexico and from Central Texas to Southern California. The original description of this plant from a collection obtained in Mexico was overlooked by Buckley, who, in 1862, published his description of the plant collected the preceding year in Texas near Eliasville. In Texas its easternmost occurrence is outlined by collections from Hardeman, Young, Bexar, Atascosa, and Webb Counties. Its westernmost occurrence in Texas is along the Rio Grande Valley in Presidio County near Porvenir, in Green Valley in Brewster County, and it has been collected in southern New Mexico adjoining Texas. It occurs in Edwards, Sutton, Schleicher, Crockett, Val Verde, Terrell, Pecos, Tom Green, Runnels, Sterling, Taylor, and Reagan Counties. The species does not occur uniformly over this area, but seems to be present in more or less abundance in well-defined but irregular areas.

SPREAD OF BITTERWEED

The bitterweed plant is known to have been present in the Edwards Plateau region in small numbers scattered here and there for many years. Obviously as conditions became favorable the plant reproduced more abundantly and began to spread over an increased area, but even so the bitterweed remained confined to low places and basins where the grass sod had been destroyed either by standing water or by the repeated deposition of silt. Such places became conspicuous in the fall and winter as a sea of green and when the plants were in bloom they appeared as a solid yellow area. Such a sight was not unusual for a long time and so long as the weed did not make itself obnoxious in any other way and did not show a tendency to spread, but only occupied areas otherwise devoid of useful vegetation it was barely given passing consideration by the ranchmen.

Official census records* show that since 1913 there has been a continuous increase in the number of sheep and goats grazed in the Edwards Plateau area so that in 1928 the sheep numbered three times as many and the goats twice as many as in 1913. From 1913 to 1923 the number of cattle increased from 650,000 to 1,000,000 and then gradually decreased until 1927, when there were again only 650,000 on the ranges, and this number fell to about 575,000 in 1928. This reduction in the number of cattle from 1,000,000 to 575,000 was evidently made because the ranchmen realized they were overstocking; but even so we find that in 1928, or about the time losses from bitterweed poisoning first became alarming, the ranges were carrying a greatly increased animal population over 1913, which probably had a marked effect upon the grass sod. This probably explains why during the last seven or eight years such a marked increase and spread of the bitterweed

*Texas Agricultural Experiment Station Bulletin No. 413.

has been witnessed. It now no longer occupies the low areas and basins only, and areas subjected to such severe tramping by livestock that the grass sod is destroyed thereby, but has also forced its way into the previously well sodded grazing lands until it is nothing unusual to find ranches where large areas that were formerly the best grazing grounds are now occupied in greater part by bitterweed, leaving only a much weakened deteriorated grass sod in between its dense growth. The main crop of bitterweeds usually germinates in November and December, and if at that time the grass sod is depleted and the soil exposed, heavy germination is favored and of course these young plants coming on at this season of the year have little competition from the grass sod as the growing season for grass has passed until the following spring. The presence of a good dense grass sod in November and December will obviously discourage the growth of young bitterweed plants at that time, and it is probable that this is one of the effective means of combating the weed.

Under favorable conditions the bitterweed makes a rapid growth and reaches a height of 12 to 14 inches where it is densely seeded. This dense growth, occupying the land at the time the grass is ready to put on its renewed growth, greatly discourages the growth of the grass and results in the continued deterioration of the grass sod. In such areas the grass is necessarily held in check until the seedlings of early fall, which are in bloom in early March, have reached their maturity by the end of May and become dry and give the grass an opportunity to continue its growth. In many cases, however, this dense covering of dry mature bitterweed will continue to greatly interfere with the growth of the grass even as late in the season as August or September. With favorable moisture conditions, the bitterweed may, however, reappear later in the season to bloom quite freely, but the plants occurring at this time have not been reported as causing any losses of sheep. This is not surprising, for now there is an abundance of other green, palatable vegetation available to the sheep.

EXPERIMENTAL WORK

In order to determine the poisonous effects of the bitterweed and to establish other fundamental facts in connection therewith, feeding experiments with bitterweed were undertaken at the Ranch Experiment Station early in 1926. Material for carrying out such experiments was at hand since the weed had in the meantime established itself upon the Station grounds. All the experiments were made with sheep. The plans called for a simple procedure which was to allow the sheep to to feed under as natural and accustomed conditions as possible and to observe whether they could be induced to eat this weed.

Feeding by Grazing

A small area was selected which showed an abundance of bitterweed. This was enclosed in movable panels and sheep placed therein for ob-

servation. The first experiment was run in February, 1926, but the sheep did not feed satisfactorily on the weed, even after being starved for almost a week. The next experiment was run in June, 1928, at a time of year when the bitterweed was already rather mature and it was thought that this might be the reason why the sheep did not eat it. This view was strengthened by the fact that the seasonal losses on the range had also ceased. Further experiments were, therefore, postponed until the next season when the bitterweed was young and tender and at a time when losses were also observed on the range. Again the sheep refused to eat the weed.

Table 1 gives a summary of the tests made.

Table 1. Sheep grazing on bitterweed

Sheep Number	Weight in pounds at		Days on test	Results
	Beginning	End		
314	.....	.....	13	Starved to death
365	.....	.....	23	Released
1357	.....	.....	23	Released
1528	.....	.....	23	Released
87	31	.....	10	Starved to death
88	39	.....	18	Starved to death
123	36	.....	18	Starved to death
218	50	.....	24	Released
219	60	.....	24	Released
252	54	39	20	Released
253	52	40	20	Released
254	39	27	18	Starved to death
255	46	31	10	Starved to death
256	48	37	16	Starved to death
257	49	36	20	Released
258	32	22	18	Starved to death
546	39	20	33	Starved to death
547	.....	.....	46	Released
548	.....	19	46	Starved to death
549	.....	.....	46	Released

In some of these tests the animals were allowed no other food while in others a small quantity of additional food was furnished, such as oats or a small amount of grazing, in order to simulate conditions on the range as closely as possible. In none of these experiments, however, did the animals ever make an attempt to do any more than nibble at the weed and the records show that ten animals are recorded as starving to death while confined to bitterweed plats from 10 to 46 days and ten animals were released from experiment after 20 to 46 days to prevent starvation.

From these preliminary tests it was concluded that the plant is normally very offensive to sheep and other means of feeding it had to be devised to determine its poisonous effects.

Feeding Sheep in Barn with Pulled Bitterweed

To test further the eating of bitterweed, experiments were undertaken in the dry feed lot or in the barn as indicated in Table 2. In these experiments the weed was pulled once or twice a day and a

Table 2. Feeding sheep fresh green bitterweed in barn

Sheep No.	Weight of animal in pounds at		Days on test	Method of feeding	Material fed	Total amount consumed	Results
	Beginning	End					
163	.....	.....	5	Ad libitum.....	Mature green plant...	Will not eat.....	Released
164	.....	.....	5	Ad libitum.....	Mature green plant...	Will not eat.....	Released
165	.....	.....	5	Ad libitum.....	Mature green plant...	Will not eat.....	Released
166	.....	.....	5	Ad libitum.....	Mature green plant...	Will not eat.....	Released
167	.....	.....	8	Ad libitum.....	Mature green plant...	Will not eat.....	Released
168	.....	.....	8	Ad libitum.....	Mature green plant...	Will not eat.....	Released
169	.....	.....	8	Ad libitum.....	Mature green plant...	Will not eat.....	Released
71	50	.....	8	Ad libitum.....	Immature green plant	2,000 gms.....	Died, bitterweed poisoning
72	40	.....	8	Ad libitum.....	Immature green plant	1,225 gms.....	Released, would not eat
74	50	.....	9	Ad libitum.....	Immature green plant	120 gms.....	Released, would not eat
85	.....	.....	13	Ad libitum.....	Immature green plant	475 gms.....	Starved to death
86	.....	.....	11	Ad libitum.....	Immature green plant	500 gms.....	Starved to death
544	70	.....	47	Ad libitum.....	Immature green plant	13,219 gms.....	Starved to death
545	95	.....	43	Ad libitum.....	Immature green plant	11,754 gms.....	Starved to death
542	62	.....	24	With C. S. meal....	Immature green plant	4,335 gms.....	Died, bitterweed poisoning
543	82	.....	50	With C. S. meal....	Immature green plant	14,514 gms.....	Released, no symptoms
245	55	39	25	With C. S. meal....	Immature green plant	4,384 gms.....	Released, no symptoms
247	46	31	25	With C. S. meal....	Immature green plant	2,966 gms.....	Starved to death
248	51	40	25	With C. S. meal....	Immature green plant	3,175 gms.....	Starved to death
249	55	37	25	With C. S. meal....	Immature green plant	2,809 gms.....	Found dead in pasture 13 days later
250	53	31	25	With C. S. meal....	Immature green plant	2,415 gms.....	Starved to death

weighed amount of the green weed offered to the sheep. That part of the weed not consumed at the end of twenty-four hours was weighed and deducted from the amount offered in order to arrive at the amount consumed. In these calculations, proper allowance was made for the drying of the material.

The first of these tests was run in the month of June, 1928, with rather mature plants and here we found, as in the grazing tests, that the animals refused to eat the weeds. When the tests were repeated in the following season with young tender weeds the animals seemed more inclined to eat them, but even then the amount consumed was rather limited. All animals on test with mature green plants were released at the end of 5 to 8 days because they would not eat. In the later experiments in which the animals were offered young green plants alone some consumption was obtained but only two cases of death occurred in these experiments that might possibly have been due to bitterweed poisoning. With the hope of increasing the consumption of bitterweed, cottonseed meal was next sprinkled over the freshly cut immature bitterweed plants offered to the sheep and with this method an increased consumption was obtained. Animals thus limited to bitterweed alone or to bitterweed with the addition of a small quantity of cottonseed meal were kept on experiment 25 to 50 days.

There is quite a variation in the individual susceptibility to the poisonous principle of bitterweed and that factor very likely is partly responsible for the variation in the reaction of the animal to the amount consumed. In these tests only two animals are recorded as dying from bitterweed poisoning. The first animal, No. 71, consumed a total of 2,000 grams immature green bitterweed during a period of 8 days or an average daily consumption of 250 grams; while the second animal, No. 542, consumed a total of 4,335 grams green immature bitterweed during 24 days or only 180 grams per day. On the other hand, Sheep No. 245 consumed 4,384 grams or 175 grams per day during 25 days, thus closely paralleling case No. 542, and yet the animal showed no symptoms of bitterweed poisoning.

Besides these cases the observer also recorded a number of cases as starved to death in which some of the sheep consumed as much as a total of 11,754 and 13,219 grams in 43 days and 50 days, respectively, or a daily consumption of 275 and 281 grams, respectively, of green bitterweed. An interesting parallel case is Sheep No. 243 which consumed 14,514 grams in 50 days, or an average of 290 grams per day without showing symptoms of bitterweed poisoning at any time. The diagnosis of starvation recorded in the above tests takes into consideration the amount of food consumed by the animal and is also largely based upon the marked emaciation and the entire absence of lesions upon post-mortem examination.

Force-Feeding of Sheep with Bitterweed

Early in the voluntary feeding experiments it was recognized that this method of testing for poisonous properties of the plant would be slow in yielding results and for that reason force-feeding was resorted to. In these experiments the dose syringe, balling gun, stomach tube, and paunch fistula were used as means of administrating the plant. The plant itself was thus fed either in the form of finely ground young green plant, or finely ground dried plant or a water extract of the finely ground plant.

The ordinary dose syringe was first tried in these experiments and the finely-ground immature green plant was employed. It was found that when the finely-ground green plant was suspended in sufficient water so that the suspension could be forced through the nozzle of the dose syringe, and this suspension merely injected into the animal's mouth, it was hard to induce the animal to swallow it. The suspension was evidently very distasteful to the animal and frequently resulted in a pneumonia, evidently as a result of strangulation of the animal. In order to avoid this it was decided to use the balling gun and place the weed in hard gelatine capsules. With this method there was not much likelihood of producing a mechanical pneumonia and no trouble was experienced on a number of cases. The stomach tube was later substituted for the balling gun and was used quite successfully. This promised to be an ideal method of administration and excluded the possibility of producing mechanical pneumonia during the process of administering the plant. Any pneumonia following the administration in this manner must needs be attributed either to the direct effects of the absorbed poisonous principle of the weed upon the lung tissue or as a result of attempts of the animal to vomit and the forcible aspiration of some of the vomited material into the lungs. Indeed in some cases evidence of inspired stomach contents was found upon post mortem, but in such cases it was believed that we were dealing with an agonal aspiration of stomach contents.

In order to get entirely away from the administration of the plant itself, water extracts from the plant were resorted to and these administered with the stomach tube. In this way it was absolutely certain that the administered material could not produce foreign body pneumonia and the lesions now found must necessarily be attributed solely to the action of the poisonous principles of the plant upon the organism. In the three experiments conducted with this water extract, a congestion of the lungs was found in two animals and a limited pneumonic area in the form of hepatization in the third animal. It is likely that this limited pneumonic area found in the third animal existed before the animal was placed on the experiment.

The results obtained in these force-feeding experiments are recorded in Table 3. In these experiments it was the aim to establish definitely whether bitterweed is poisonous and for that reason the

Table 3. Force feeding with bitterweed

Sheep No.	Weight, pounds	Days on test	Method of feeding	Material fed	Amount bitterweed consumed	Results
92*	61	17	Balling gun	Immature green plant	1792 gms. +11,503 c.c. water extract	No symptoms
261	66	3	Balling gun	Immature green plant	694 gms. + 3,020 c.c. water extract	Bitterweed poisoning
262	76	3	Balling gun	Immature green plant	791 gms. + 800 c.c. water extract	Bitterweed poisoning
605	67	2	Balling gun	Dry ground bitterweed	200 grams	Sick, recovered
606	66	3	Balling gun	Dry ground bitterweed	300 grams	Bitterweed poisoning
CS2	73	3	Balling gun	Dry ground bitterweed	384 grams	Bitterweed poisoning
321	81	2	Stomach tube	Immature green plant	500 grams	Bitterweed poisoning
326	87	2	Stomach tube	Immature green plant	700 grams	Bitterweed poisoning
328	.....	2	Stomach tube	Immature green plant	700 grams	Bitterweed poisoning
323	65	5	Stomach tube	Immature green plant	1250 grams	Bitterweed poisoning
320	77	11	Stomach tube	Immature green plant	1100 grams	Remained healthy
319	69	3	Stomach tube	Immature green plant	750 grams	Bitterweed poisoning
313	88	7	Stomach tube	Immature green plant	1700 grams	Bitterweed poisoning
312	83	3	Stomach tube	Immature green plant	750 grams	Bitterweed poisoning
311	106	3	Stomach tube	Immature green plant	1250 grams	Bitterweed poisoning
236	.....	5	Paunch fistula	Immature green plant	700 grams	Bitterweed poisoning
608	55	2	Stomach tube	Water extract of dried ground bitterweed	844 grams	Bitterweed poisoning
609	.....	3	Stomach tube	Water extract of dried ground bitterweed	1256 grams	Bitterweed poisoning
616	.....	17	Stomach tube	Water extract of dried ground bitterweed	6330 grams	Bitterweed poisoning
CS1	120	3	Stomach tube	Water extract of dried ground bitterweed	750 grams	Remained healthy

*Mechanical pneumonia induced on 17th day of test resulting in death.

weed was in many cases probably administered in greater quantities than necessary to kill the animal. It is shown in Table 3 that out of 20 animals forcibly fed on bitterweed, 16 died of bitterweed poisoning, 1 was made sick but recovered, while the remaining 3 showed no symptoms. Marked variation in the quantity necessary to kill the animal is rather striking and perhaps worthy of note. Attention is especially directed to three cases, CS1, 320, and 92 in Table 3. Sheep CS1 received the water extract from 750 grams of dried bitterweed in the course of three days while Sheep 320 received 100 grams of immature green bitterweed each day for 11 successive days. Neither of these two animals showed symptoms of bitterweed poisoning. Sheep 92 received 105 grams of immature green bitterweed plus 676 cc. water extract of the weed daily for a period of 17 days without manifesting any harmful effects up to the 17th day when the animal was strangled while attendants were administering a capsule. It is not known why the sheep have shown such a variation in resistance to the poisonous effects of the weed. As can be seen from the table, there are still other cases that also showed a marked resistance to the poisonous effects of the weed. An interesting record is that of Sheep 605 and 606. In Sheep 605, 200 grams of dried ground bitterweed given in the course of two days produced illness of the animal but it recovered; but in case of Sheep 606, 300 grams of dried ground bitterweed was administered in the course of three days and the animal succumbed to bitterweed poisoning.

On the other hand, when larger quantities of bitterweed were administered over a comparatively short time, death invariably followed. It seems that as little as 500 grams of the green immature bitterweed, when given over a period of two days, is sufficient to cause the death of some animals. It is very unlikely that sheep, considering the disagreeable taste of the weed, would ever partake voluntarily of that much bitterweed on a range where there is a plentiful supply of harmless succulent vegetation at their disposal.

SYMPTOMS AND LESIONS

The symptoms of bitterweed poisoning vary in degree rather than otherwise according to the quantity of bitterweed eaten. When taken in small quantities the weed undoubtedly must be taken for some days before the animal becomes noticeably ill, and if at this time the animal should be removed from the bitterweed range, it will recover in the course of a few days. When such a recovered animal is again turned upon the bitterweed range, it will again require some days before the animal has partaken a sufficient amount of bitterweed to make it sick. One may speak of such light cases of bitterweed poisoning as sub-acute cases. When such a case is observed on the range, it is only logical to remove it to premises free from bitterweed, and, if need be, to offer some supplemental feed.

It frequently happens on the range that animals succumb to the poisonous effects of bitterweed within a comparatively short time, and such cases may be spoken of as the acute type of bitterweed poisoning. In these cases, one observes complete loss of appetite, cessation of rumination, depression, indications of abdominal pain, bloat, frequently a light froth at the mouth and many times a discharge from the nose stained a deep green with plant coloring matter. Thus we found abdominal pain manifested by the animal standing with its back arched and indisposed to move or it moves only slowly. This symptom, sometimes accompanied by bloat, was observed in 7 out of 17 experimental cases, while a froth at the mouth or a greenish discharge from the nose was recorded in 8 out of 17 experimental cases. The pulse was frequently greatly accelerated, sometimes irregular and the body temperature normal or subnormal. Accelerated respiration was not recorded, but labored breathing accompanied by audible rales was observed in a few cases. Vomiting was observed for only one out of 17 experimental cases.

Perhaps the most constant post morten lesion observed is a congestion of the lungs. This lesion is sometimes so marked that one is tempted to speak of hepatization of the lungs. The next most constant lesion observed is the presence of hemorrhages on the epicardium, which in a few cases have also been observed upon the endocardium and upon the costal pleura. The lymphnodes, especially the submaxillary and retropharyngeal, also are very frequently markedly hemorrhagic or congested. The first three compartments of the stomach are normal as a rule and in only a few instances show minor lesions such as a few small, lightly congested areas in the rumen. In two out of 17 experimental cases a small area of gelatinous infiltration on the external surface of the rumen between the folds was observed. In the main, therefore, the first three compartments of the stomach are not affected, but the remainder of the intestinal tract frequently shows rather marked lesions. The fourth stomach is perhaps the most severely affected of the entire intestinal tract, and here the lesions consist of a congestion or even of hermorrhages in the majority of the cases. Similar lesions may also be found scattered throughout the intestinal tract and are especially encountered in the duodenum. The other organs do not always show very marked changes. The spleen may be tumefied and the pulpa slightly softer than normal, the kidneys may be congested or show petechiae, and the liver may be congested and friable.

From these symptoms and lesions it is obvious that with the exception of the possible presence of a greenish discharge from the nose and the abdominal pain that is frequently manifested by the animal suffering from bitterweed poisoning, nothing is found that may not also be observed in other troubles, but when encountered within the bitterweed area calls for mature deliberation and judgment on the part of the diagnostician.

DISCUSSION

In reviewing the data one is struck with the fact that bitterweed is very distasteful to sheep and that sheep frequently, when confined upon areas showing an abundance of bitterweed, ran the risk of starving to death rather than eat the weed. Another striking fact observed in the field is that bitterweed poisoning is only reported during a time when there is no other green vegetation at hand, and in fact, under conditions when other succulent vegetation is scarce. It is not at all unlikely that had the animal a sufficient amount of palatable, harmless vegetation at its disposal, it would not at any time feed upon this bitterweed. The control of bitterweed poisoning in sheep, it would seem, could be materially effected if succulent feed in some form were available, for it seems that this craving for succulent feed is one of the main factors in inducing the animals to eat bitterweed. The establishment of a good grass sod and the consequent exclusion of the bitterweed as the principal succulent plant, coupled with the presence of harmless succulent plants is, therefore, of the greatest importance.

Experiments are now under way at the Ranch Experiment Station that are expected to throw more light upon the influence of the rate of stocking upon the spread of bitterweed to areas previously unoccupied by it and more particularly to determine whether with adjusted stocking the grass sod can be re-established sufficiently to enable it to crowd out the bitterweed and remove it from ranges so that it will no longer constitute a menace to useful vegetation and to livestock. These experiments are based upon the assumption that the bitterweed, as an annual, is unable to compete successfully with grass where a good sod is present in November and December, when bitterweed germination takes place. Special attention will be directed at finding some practical means of destroying the bitterweed in the basins and other low areas where the grass sod has been destroyed by standing water or the deposition of silt and cannot be successfully re-established until the responsible process ceases to operate. As long as such areas remain and the bitterweed there is permitted to produce annually millions of seed, they constitute a hazard to the remainder of the range.

SUMMARY AND CONCLUSIONS

1. Results obtained by feeding bitterweed to sheep are reported and a botanical description of the plant, its approximate present distribution and its relative abundance in the different localities are given.

2. Bitterweed makes its appearance in the early fall and matures during the latter part of April and May. During this period heavy losses among sheep have been reported in the Edwards Plateau region and commonly attributed to the sheep eating bitterweed.

3. The rapid spread of the bitterweed during the last eight or ten years from small basins and other low areas to higher ground and its relationship to losses from bitterweed poisoning is indicated.

4. In grazing tests under controlled conditions the sheep consumed practically no bitterweed in the face of starvation.

5. In feeding tests in the barn with fresh pulled bitterweed the animals refused to eat the bitterweed except in small amounts when almost starved.

6. Animals were readily poisoned by force-feeding with bitterweed. Sixteen of twenty experimental animals succumbed. The accurate minimum lethal dose of bitterweed for sheep has not been determined since work so far undertaken concerned itself mainly with determining the poisonous character of this weed.

7. The susceptibility of sheep to bitterweed poisoning seems to vary with different individuals. In some cases as little as 500 grams of immature green bitterweed when given over a period of two days was sufficient to cause the death of the animal. Other animals have been found that tolerated much larger amounts without succumbing to bitterweed poisoning.

8. The symptoms and lesions of bitterweed poisoning in sheep are recorded and discussed.

9. Animals showing the first symptoms of bitterweed poisoning should be removed from the range and given supplemental feed.